

What is the effect of the Swiss climate policy mix on the energy consumption and emissions of firms in the industry and service sector?

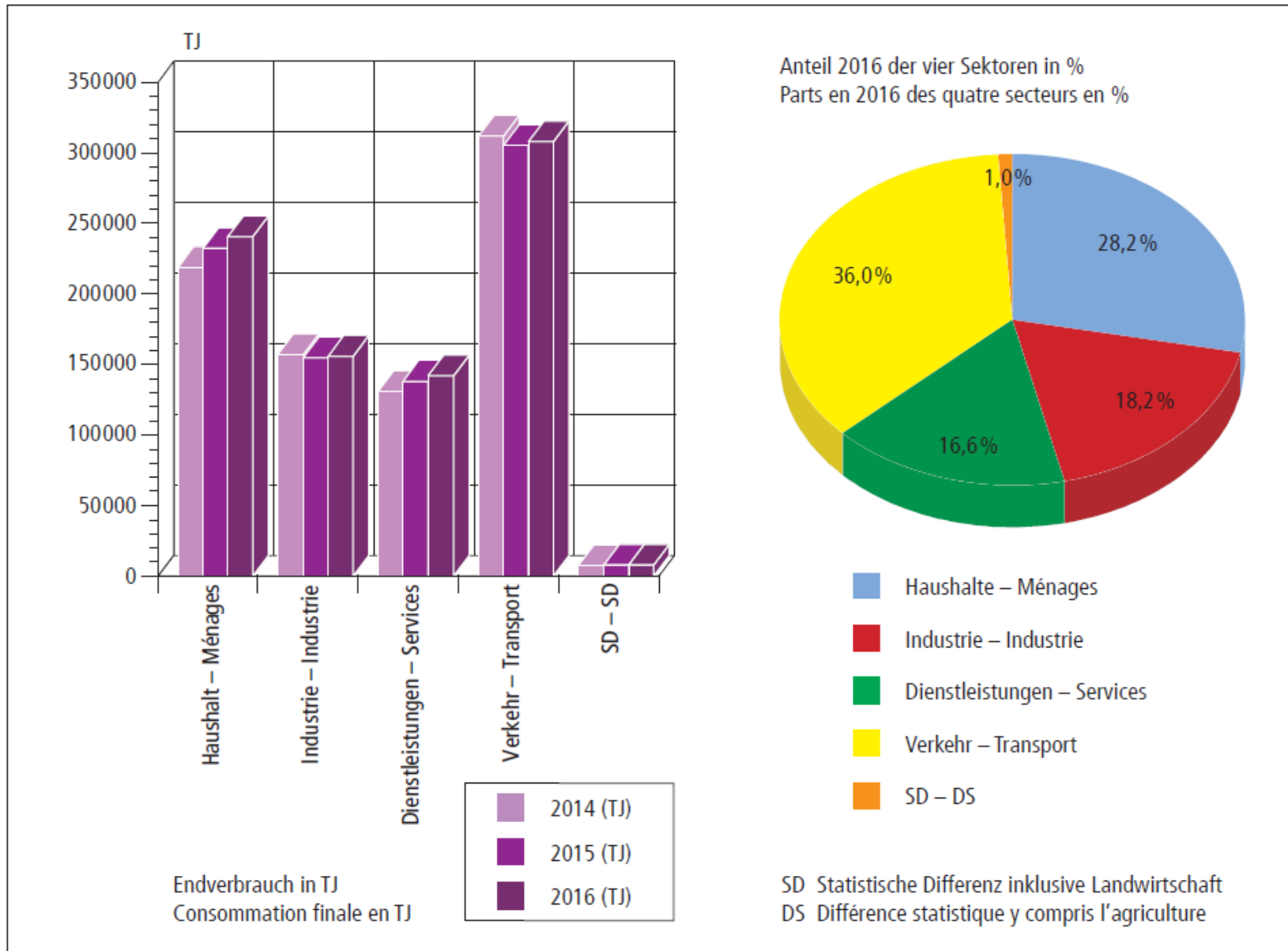


Building Competence. Crossing Borders.

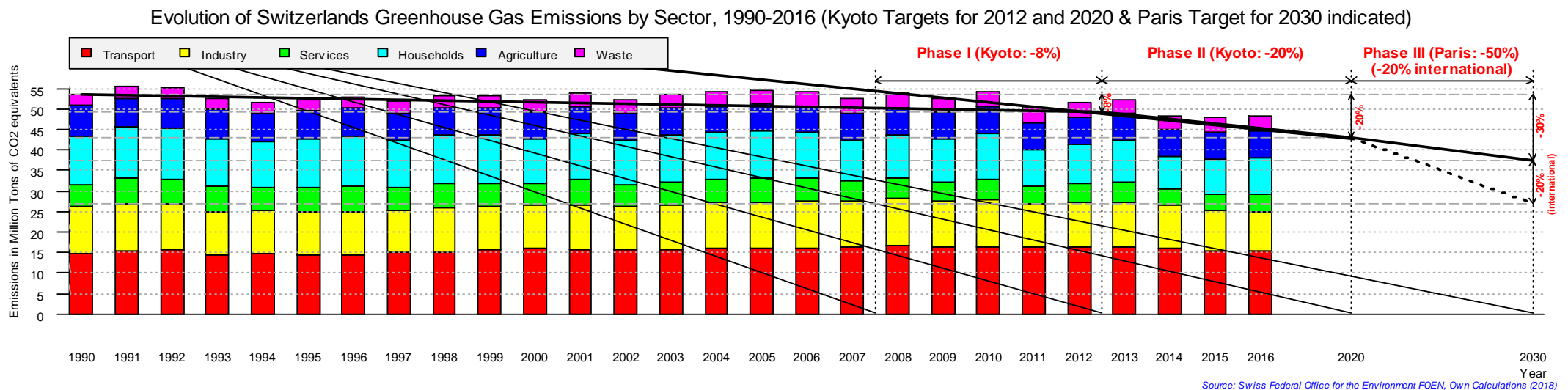
Thomas Leu, Dr. Tobias Müller

thomas.leu@zhaw.ch, tobias.mueller@zhaw.ch, 29 May 2018

Distribution of final energy consumption by sector 2016



Evolution of Switzerland's greenhouse gas emissions by sector, 1990 – 2016 (Data source: FOEN)



- 2016: Industry and service sector account for 29% of the total greenhouse gas emissions in Switzerland
- Persistent shares of the two sectors over time

Research Question

Main research question: What is the effect of the Swiss climate policy mix on firms energy consumption and CO2 emissions in the industry and service sector?

- Ex-post evaluation of the Swiss climate policy mix (CO2 levy, target agreement, CH ETS) introduced in 2008

Substantive subquestions

- How did firms reduce their CO2 emissions?
 - Analysis of **substitution patterns**
- What types of firms account for most of the CO2 reductions?
 - **Effect heterogeneity** by amount of emissions/consumption

Previous Literature

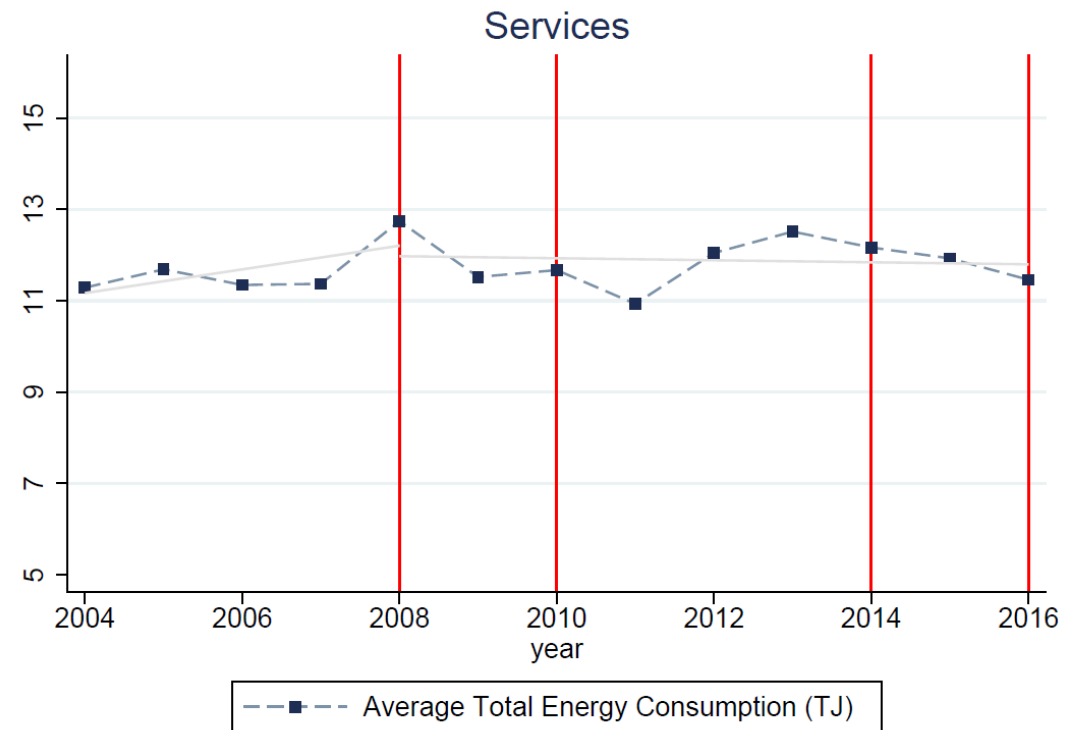
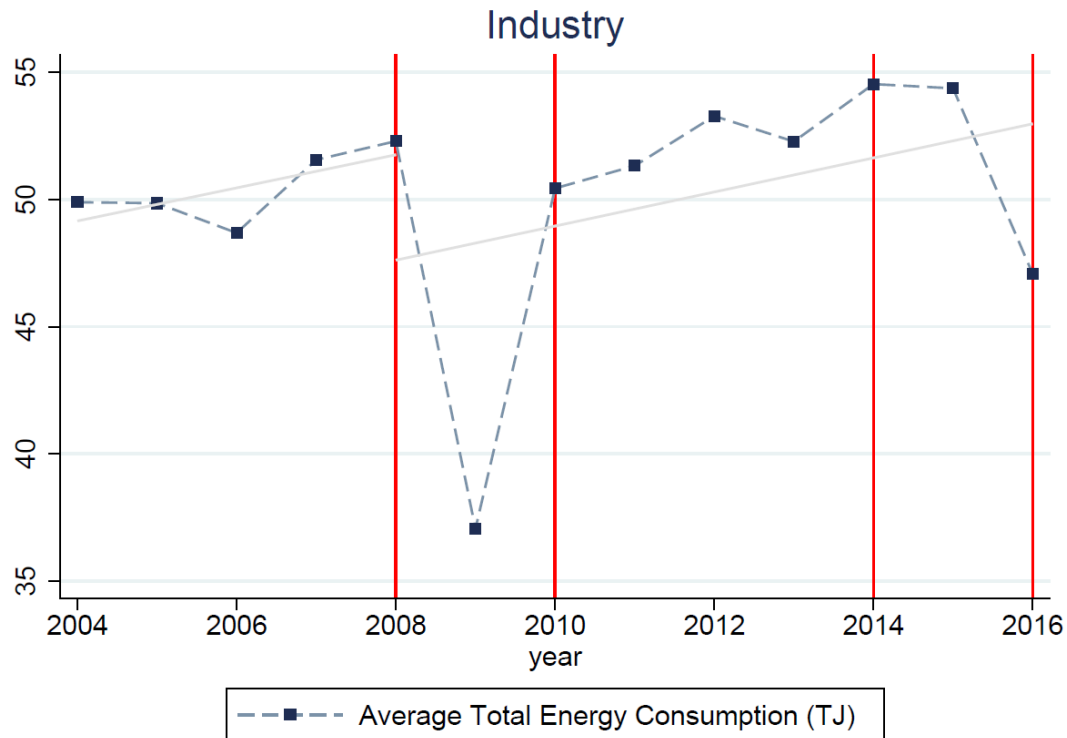
- Environmental Tax Evaluation. What can be learnt so far?
Leu, T., & Betz, R. (2016):
 - *Detailed overview of ex-post evaluations of explicit carbon taxes*
- The impact of a carbon tax on manufacturing: Evidence from microdata.
Martin et al., Journal of Public Economics (2014):
 - *DiD estimates indicate that the introduction of a carbon tax had a strong negative impact on electricity use and CO2 emissions of plants in the UK*
- Wirkungsabschätzung CO2-Abgabe: Synthese. Ecoplan, EPFL, & FHNW. (2015). Report on behalf of the FOEN:
 - *CO₂ mitigation varies between 2.5% to 6%*
 - *Substitution patterns observable as firms/households consume less heating oil and substantially more natural gas post 2008*

Data

Firm-level (panel) data from the Swiss Federal Office of Energy (SFOE) for the years 1999-2016

- **Sample construction:** Restriction to firms that provide information pre- and post-policy
- **Estimation sample:** 19'721 observations from **1727 firms**
- **Outcome variables**
 - Overall energy consumption and by energy sources (in TJ)
 - CO2 emission overall and by energy sources (in tons)
- **Firm characteristics**
 - Sector and industry indicators, number of full- and part-time employees, firm size (floor area)
- **Aggregated information**
 - GDP growth, Stock market indices, Industrial production index, Oil price index, Heating degree days

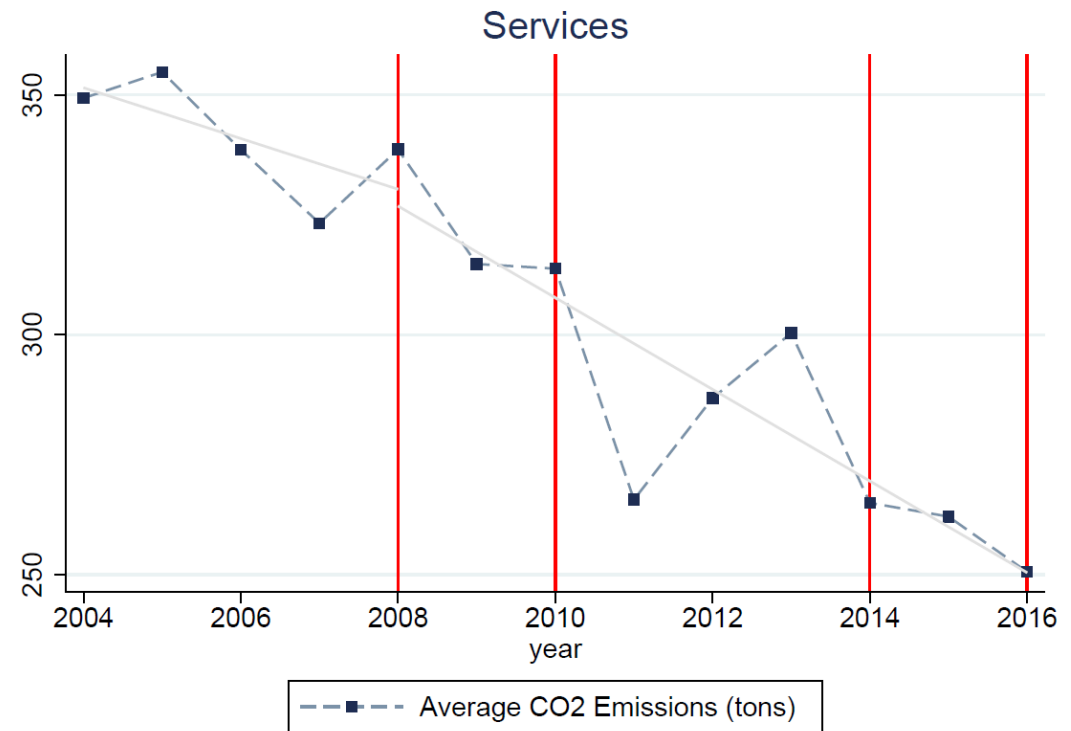
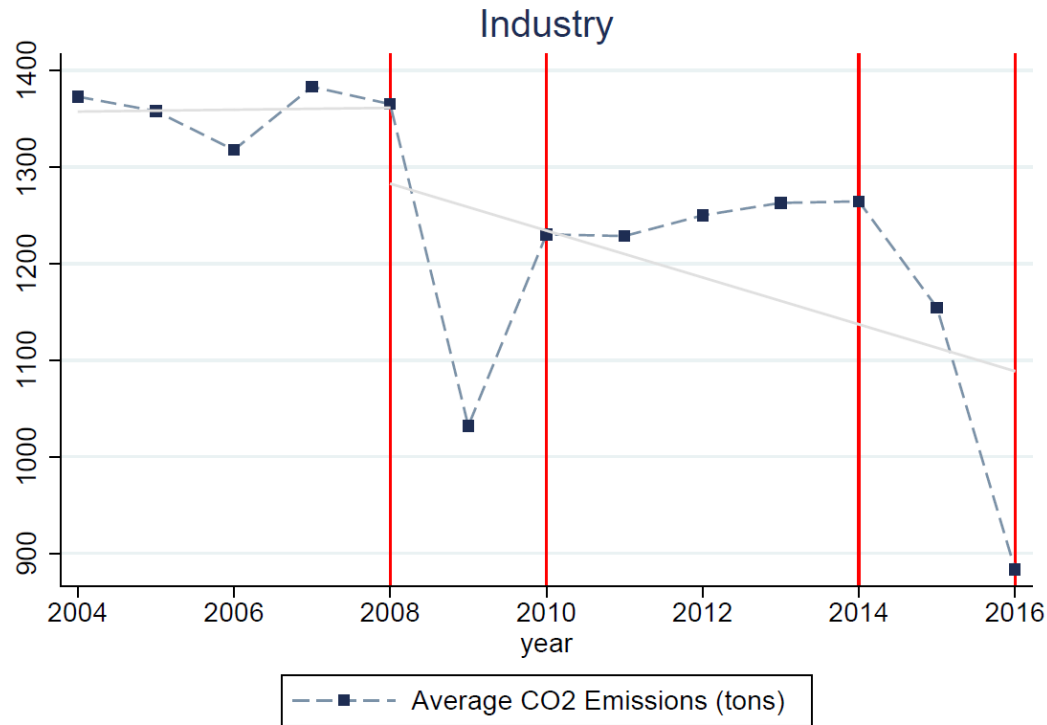
Big picture: Energy consumption (in TJ)



Industry: Positive trend in overall energy consumption post-policy (after 2008)

Services: Stable energy consumption pre- and post-policy

Big picture: CO2 Emissions (in tons)



Industry: Sharp reduction and distinct negative trend in CO2 emissions post-policy

Services: Ongoing negative trend in CO2 emissions already before the policy change

Summary statistics pre- and post-policy

	Mean	S.D.	N		Mean	S.D.	N
Pre-policy period				Post-policy period			
<i>Outcomes</i>				<i>Outcomes</i>			
Total Energy Consumption	36.78	202.39	5766	Total Energy Consumption	36.73	194.62	12438
Total CO2 Emissions (tons)	995.30	4891.83	5766	Total CO2 Emissions (tons)	879.97	4591.56	12438
Heating Oil extra light in TJ	3.57	10.56	5766	Heating Oil extra light in TJ	2.28	6.7	12438
Heating Oil medium / heavy in TJ	0.96	21.3	5766	Heating Oil medium / heavy in TJ	0.35	9.93	12438
Natural Gas in TJ	11.25	76.2	5766	Natural Gas in TJ	11.92	77.88	12438
Natural Wood in TJ	0.3	4.11	5766	Natural Wood in TJ	0.43	5.26	12438
Old Wood, Scrap Wood in TJ	0.78	15.69	5766	Old Wood, Scrap Wood in TJ	1.6	43.85	12438
Net Electricity Consumption in TJ	16.07	96.98	5766	Net Electricity Consumption in TJ	15.79	84.45	12438
<i>Firm characteristics</i>				<i>Firm characteristics</i>			
Service sector	0.36	0.48	5766	Service sector	0.36	0.48	12438
Number of full-time employees	153.44	220.22	5766	Number of full-time employees	170	264.63	12438
Number of part-time employees	32.96	93.15	5766	Number of part-time employees	45.72	137.5	11425
Gross Floor Area in m^2	14109.12	28358.78	5766	Gross Floor Area in m^2	14942.62	24670.17	12438

Pre-post-comparison

- Stable average energy consumption of firms
- Substantial reduction in average CO2 emissions
- Shift away from light/medium/heavy heating oil mainly towards natural gas and wood

Empirical strategy

Main empirical goal: Isolate the effect of the Swiss climate policy mix on the energy consumption and CO2 emissions in the service and industry sector

Empirical challenges

- Firms **self-select** into different climate policies
 - **No information** in the data available regarding the question **what policies** apply to specific firms!
 - **Implication:** Isolation of the effects of specific policies (e.g. CO2 levy) on firm energy consumption/emissions not possible at the moment
- Disentangling the different **channels** (e.g. economic activity, oil price, policy effect) explaining the observed reduction in the firms energy consumption and emissions

Empirical strategy

How to capture the effect of the policy mix on firms energy consumption and emissions?

Two-part empirical strategy

- **Fixed-effects** specifications to capture **average** policy effects
 - Exploit within-firm variation to estimate the effects for a typical firm in the sample
 - Control for unobserved time-invariant firm differences affecting energy consumption/emissions
- **Quantile Regression** to capture **distributional** effects of the policy
 - Estimate the effects of the policy at different quantiles of the corresponding outcome distributions
 - Answers e.g. the question whether larger firms reduced their emissions more heavily than smaller ones

Average policy effects

How do we capture average policy effects?

Fixed-effects specification

$$y_{it} = \alpha_i + post_policy_t \tau + x'_{it} \beta + a'_t \gamma + \varepsilon_{it}$$

where

- y_{it} : Energy consumption/emissions of firm i in year t
- α_i : Firm fixed-effect (e.g. attitude of management towards clean energy)
- $post_policy_t$: Dummy for post-policy years (baseline: pre-policy period)
- x_{it} : Vector of firm-specific characteristics (e.g. firm size, number of employees)
- a_t : Vector of aggregate indicators (e.g. GDP growth, oil price changes)
- ε_{it} : Idiosyncratic error term

Results: Average policy effects in the industry sector

Average Policy Effects: Industry				
Outcome Variable	Total		Light oil	
	ln(consumption)	CO2 emissions	ln(consumption)	CO2 emissions
<i>Post Policy_t</i>	0.01 (0.01)	-122.50* (57.96)	-0.31** (0.03)	-118.46** (17.25)
Firm fixed-effects	Yes	Yes	Yes	Yes
Firm characteristics	Yes	Yes	Yes	Yes
Economic activity indicators	Yes	Yes	Yes	Yes
Oil price	Yes	Yes	Yes	Yes
Number of observations	10743	10743	7333	10743

Overall

- Overall **energy consumption** essentially **unchanged** after the policy
- Highly **significant reduction** in overall **CO2 emissions** by 122 tons for the average firm in the industry sector

Light oil

- **Significant reductions** in both the light oil consumption and the corresponding CO2 emissions

Results: Average policy effects in the industry sector

Average Policy Effects: Industry					
Outcome Variable	Heavy oil		Natural gas		Net electricity
	ln(consumption)	CO2 emissions	ln(consumption)	CO2 emissions	ln(consumption)
<i>Post Policy_t</i>	-0.60 (0.32)	-55.30 (43.18)	0.09* (0.04)	65.65* (32.90)	0.06** (0.01)
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes
Firm characteristics	Yes	Yes	Yes	Yes	Yes
Economic activity indicators	Yes	Yes	Yes	Yes	Yes
Oil price	Yes	Yes	Yes	Yes	Yes
Number of observations	6721	10743	4024	10743	10743

Heavy oil

- **No changes** in the heavy oil consumption/emissions pre-post-policy

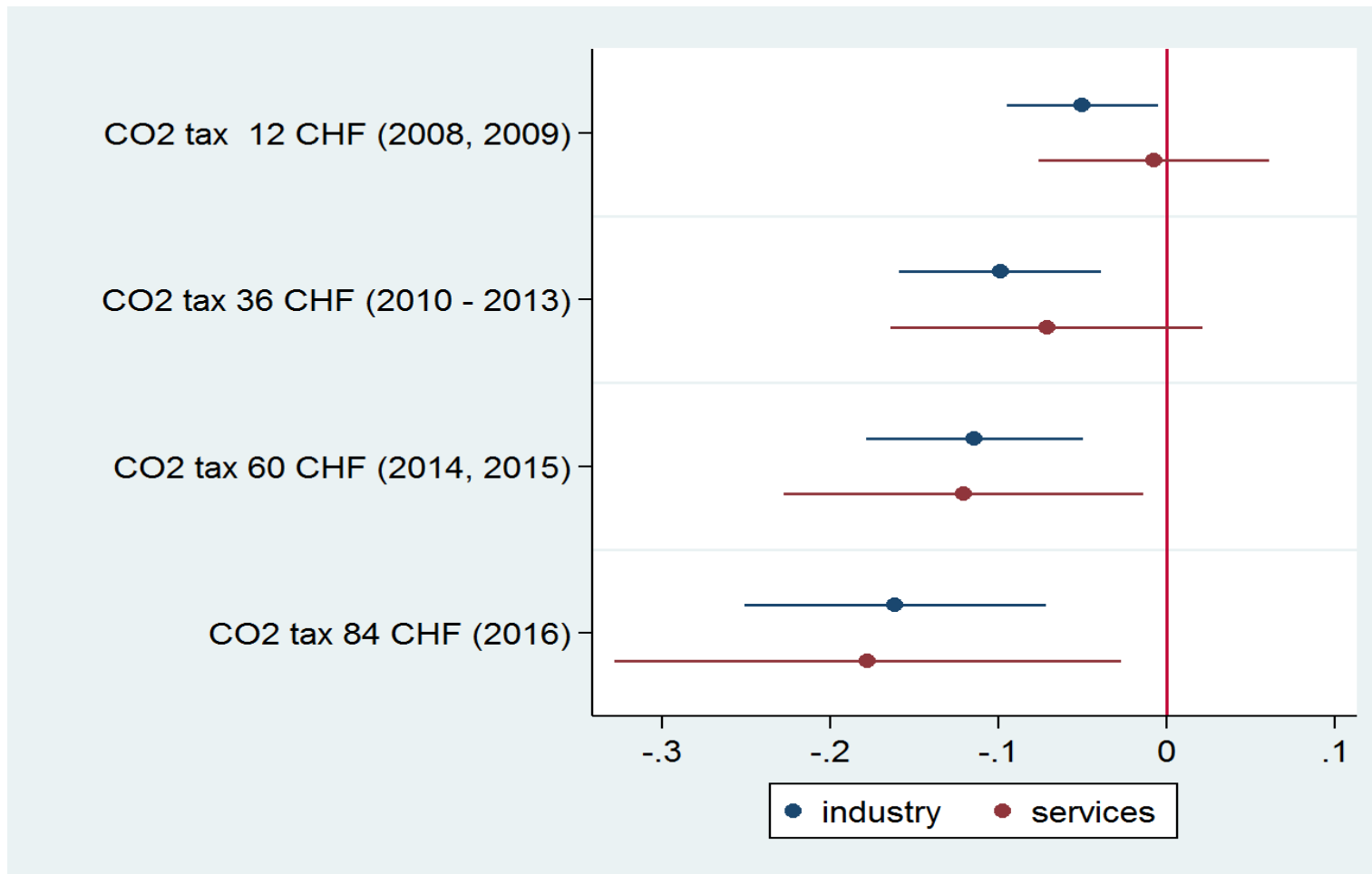
Natural gas

- Significant **shift towards natural gas** consumption/emission post-policy

Net electricity

- **Significant increase** in electricity consumption

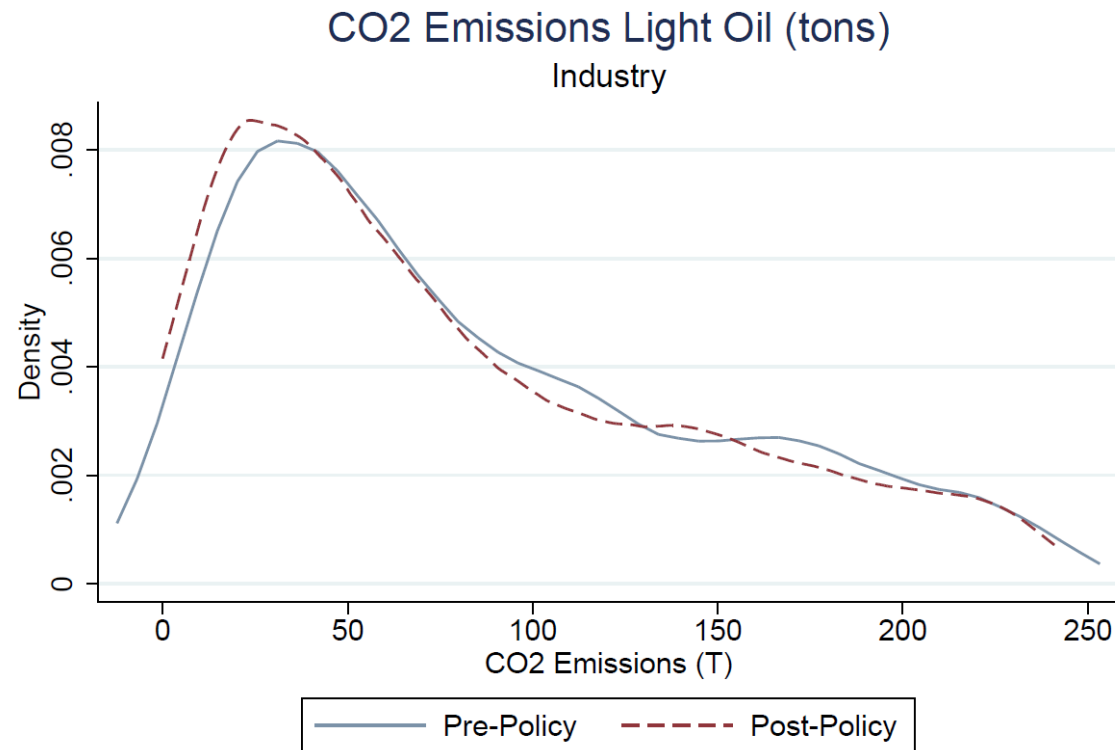
Results: Dynamic average policy effects on fossil fuel consumption



- Exploiting the variation in tax levels over time suggests a significant **negative impact of CO2 taxes** on fossil fuel consumption

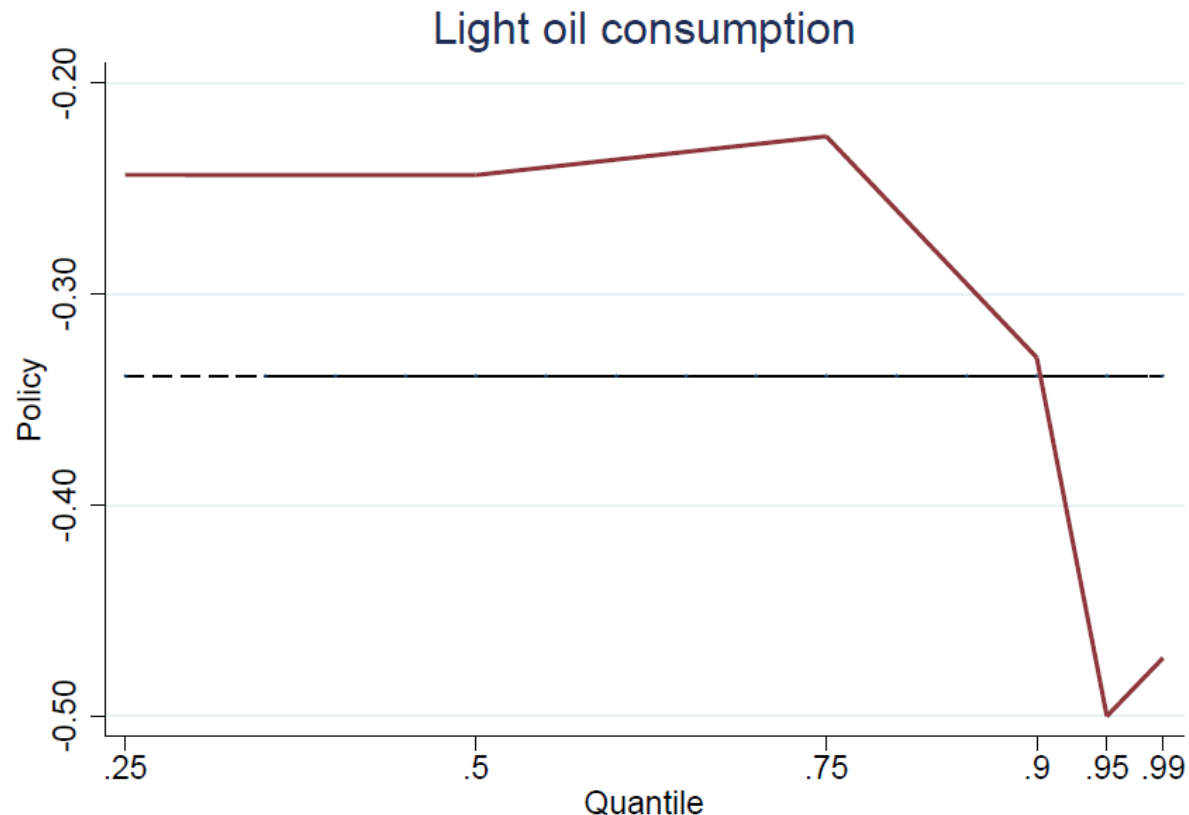
Motivation: Distributional effects

Going beyond average policy effects...



- Inspection of the data shows that, e.g., the **whole distribution** of CO2 emissions from light oil consumption has moved to the left in the post-policy period and the upper tail of the distribution has lost probability mass

Preliminary analysis: Effect heterogeneity



- **Substantial effect heterogeneity** between firms of different size
 - Firms at the median of the light oil consumption distribution reduce about 25% of their consumption in the post-policy period (same is true for firms below the median)
 - Interesting: Firms in the upper part of the distribution reduce their consumption between 25-50%
 - Top 1% consumers reduce their consumption by 47%

Conclusion

So what is the effect of the Swiss climate policy mix on firms energy consumption and CO2 emissions in the industry and service sector?

- Our analysis shows **substantial reductions in the CO2 emissions** for the average firm in the industry and service sector post-policy
- **Substitution patterns:** The typical firm moves away from light oil towards natural gas and electricity consumption
- Preliminary analysis indicates substantial **effect heterogeneity** between firms of different size as larger fossil fuel emitters/consumers tend to respond more heavily to the policy change

Limitations: Without the exact information about the firm-specific policies, no conclusions can be drawn regarding the effects of, e.g., the CO2 levy...

Outlook

Further isolation of the effect of CO₂ taxes on emissions:

- Construct firm-specific weighted (average) carbon taxes, with weights corresponding to firm shares of different energy sources (i.e. light fossil fuel, natural gas etc.) that differ in their CO₂ and **tax intensity**
- Firms with larger shares of higher taxed fossil fuels reduce CO₂ emissions relatively more
- Preliminary FE estimations show a significant negative effect of the average carbon taxes faced by individual firms on CO₂ emissions

Further disentangling the effect of energy policies from other confounding trends (technological progress etc.) by additional difference-in-difference estimations